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GRADUATE SCHOOL

THESIS

ARITHMETIC NEEDED IN THE TEXTILE INDUSTRY

BY

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OUTLINE

Arithmetic Needed In The Textile Industry

I. Introduction.

II. Development of the Textile Industry in the United States.

III. The Tariff and the Textile Industry.

IV. The Scope of the Industry.

V. The Story of Making Wool into Cloth.

VI. The Lowell Textile School.

VII. Measures Used in the Textile Industry.

VIII. Typical Examples.

IX. Schooling Required.

X. Visits to Manufacturing Plants.

XI. Summary.

XII. Conclusion.

XIII. Glossary.

XIV. Bibliography.

I. INTRODUCTION

The purpose of this investigation was to find out what arithmetic is needed in the textile industry. In order to get this information it was necessary to know something of the history of the industry and its importance to America. While examples are drawn from the different divisions of the industry, the woolen industry is studied more in detail.

The study of the tariff question as it is related to the textile industry is important because it involves figuring. A knowledge of the calculation involved is gained from a study of typical textile calculations and the curriculum of the Lowell Textile School. Other information was gained with wool dealers, and conferences with Mr. Samuel S. Dale, an authority on weights and measures, and Mr. F. Nathaniel Perkins, Secretary of Boston Wool Association.

II. DEVELOPMENT OF TEXTILE INDUSTRY IN UNITED STATES.

The study of the textile industry is important not only because it supplies clothing, one of the three fundamental necessities of civilized man, but because it is vitally concerned with the economic history of the world at large, and of America in particular.

Doubtless the settlement of America was due in a large degree to the sheep raising industry in England in the early part of the seventeenth century. Due to the scarcity of labor following the "Black Death," large agricultural lands were turned into sheep pastures. As a result of this new enterprise, and the consequent manufacture of cloth, England was faced with serious economic conditions. It was hoped that colonization of America would offer a solution to the problem of unemployment and at the same time furnish markets for manufactured products of England.

Since the sheep raising industry was so important at this time, it was quite natural for the early settlers in Virginia, Massachusetts, and New York to be interested in the industry.

The first sheep were said to have been brought to Jamestown, Virginia, in 1609. The loom and spinning wheel were familiar articles in every home. Early legislation emphasized the importance of sheep raising. In 1645 Massachusetts enacted a law for the encouragement of raising of sheep, and in 1856 required each family to spin three pounds of wool, cotton, or flax per week for thirty weeks of the year. In 1856 a skilled weaver settled in Lowell, Massachusetts, which in time became one of the leading cities in manufacture of textiles.

In 1662, Virginia not only forbade the exportation of wool but offered five pounds of tobacco for every yard of cloth made in the colony. It was a sign of patriotic devotion to appear in homespun. It is said that "Harvard Class of 1770" appeared in black cloth of New England manufacture. In 1785, South Carolina offered a medal for the first flock of Merino sheep kept in the State. These were all evidences of the growth of Nationalism.

In 1895, Mr. Theodore C. Search, addressing the National Association of Wool Manufacturers, stressed the need for industrial independence as well as political independence.

He showed that natural resources, character of people, and home markets for products were all favorable for industrial preeminence. He deplored the fact that in spite of the "McKinley Tariff" we were importers of $100,000,000 worth of goods manufactured wholly of wool, cotton or silk.

Both England and America are still interested in the textile industry. In Great Britain today the Wool Industries Research Association sponsored by the Department of Scientific and Industrial Research, is trying to attain the following obectives:

(1) Improvement of machines in order to save time and reduce expenses in carding and spinning processes.

(2) Perfection of a new principle of worsted spinning, giving effective control of fibers down to 3/4 inch.

(3) Search for new uses of wool by subjecting wool to various treatments.

(4) Research in finishing processes to get new ways of bleaching and dyeing.

Research is also being carried on in the United States in order that wool may help

Reference: Department of Scientific & Industrial Research, London, 1930-1931

solve the economic problems of today. In the Boston Evening Transcript for Thursday, January 21, 1932 was the encouraging article, "Wool Leading New England Textiles Back Toward Normal."

Mr. Carl G. Fowler says, "Few if any of the raw commodities equal wool in price stability and statistical strength today. This outstanding position is occupied after a year of record clip. It testifies to the substantial consumption of the wool manufacturing industry in 1931. As Boston dominates the country in wool, and New England in its manufacture, with Massachusetts alone accounting for a large share of the machinery in the industry, these are facts vital to the current textile and general economic situation in this territory. True the manufacturing industry ran into circumstances which prevented a profitable turnover on the great production of last year, but as stated by the new president of the Boston Wool Trade Association, Robert L. Turnbull, the stability of the wool market will definitely benefit the goods market in the near future.

"Both in the cotton and wool industries, last year was a time of active production, though without satisfactory results in financial returns.

Reference: Boston Evening Transcript January 21, 1932

Given a continuation of substantial production this year, however, the chances should be favorable for profits, since the liquidation of raw material has proceeded to the fullest extent likely and other costs, including wages, have been reduced. The textile industries as a whole have been notably active, especially compared with other lines, as rayon production rose to a new record in 1931 in response to increased consumption. Such production is no assurance of a profitable year in 1932, but at least it can be said that all textile branches have been working hard to adjust themselves in a way to profit from active manufacturing.

"Boston dealers buy and distribute over 350,000,000 pounds of raw wool annually, which is equivalent to a very large part of the domestic clip. A great part of this distribution, moreover, is confined to New England, since the machinery of this district in 1931 averaged 60 percent of the consumption for the country. The actual amount reported in Government statistics, domestic and foreign wool, was approximately 295,000,000 pounds. A conservative estimate of the amount unreported is 60,000,000 pounds. The industry is modernizing itself constantly and some mills are reported to

have made profits in a poor year by the installation of new equipment for old. According to one authority, meantime, the spindle-age as of July 1, 1931, was 4,637,212 for the country, 2,935,626 for New England and 1,394,651 for Massachusetts; looms: 76,510 for the country, 44,230 for New England and 22,902 for Massachusetts.

"Statistics recently issued indicate the sales of standard cotton cloths and shipments in 1931 were ahead of production. Stocks were reduced and unfilled orders increased substantially. The balance of operations among mills of the country as a whole is said to have been improved very much, which is to the ultimate advantage of New England. For the present, New England cotton manufacturers are concerned with some of the most notable efforts in the country toward better merchandising methods with their goods. With competition less severe, the results of their endeavors will become more apparent. Figures of machinery in place on July 1, 1931, the latest available, give New England 35 percent of the ring spindles in the country, 26 percent of the twisters and 40 percent of the looms; Massachusetts 6,034,893 of 10,647,243 ring spindles in

New England: 392,372 of 564,834 twisters and 135,266 of 260,149 looms.

These figures do not indicate the same percentages of production, owing to the variation in hours of operation. They do, however, reflect a continuing great importance of the industry to New England and Massachusetts.

Reference: Fowler, Carl G. "New England Faith in the Present."

The following table indicating the number of workers employed in the industry shows how important the industry is for the United States.

TABLE I.

Industry	Establishments Reporting	Number on pay-roll Feb. 1932
Textiles & Their Products	2,733	590,501
Cotton Goods	546	194,193
Hosiery & Knit Goods	420	100,867
Silk Goods	268	50,050
Woolen & Worsted Goods	202	52,819
Carpets & Rugs	32	14,824
Dyeing & Finishing Textiles	146	37,712
Men's Clothing	347	59,055
Shirts & Collars	113	14,584
Women's Clothing	399	27,843
Millinery	125	10,348
Corsets & Allied Garments	31	5,809
Cotton Small Wares	103	9,833
Hats, fur-felt	36	5,236
Men's Furnishings	78	7,328

Reference: U. S. Bureau of Labor Statistics
Feb. 1932 "Trend of Employment."

These figures do not cover the whole industry. Bulletin 533 U. S. Bureau of Labor Statistics report 41,400 wage earners in 105 representative woolen and worsted mills in 15 states. This number is estimated as only 27% of the total figures which would be approximately 150,000 workers.

U. S. Bulletin No. 541 gives the following statistics:

Industry	Number of Establishments	Number of States	Number of Workers
Cotton Goods	162	11	90,053
Dyeing & Finishing Textiles	109	8	21,482
Hosiery	122	19	33,827
Underwear	74	15	15,155
Men's Clothing	212	14 cities	33,404
Rayon	21		38,938
Silk Industry of Pa.	62	1	17,000
Woolen & Worsted	105	15	41,400

Reference: U. S. Bureau of Labor Statistics No. 541
Handbook of Labor Statistics 1931

The following table gives employment data for 206 manufacturing establishments in Massachusetts for one week in February and March 1932.

Industry	No. Establishments reporting	No. Employed Feb.	No. Employed March
Carpets & Rugs	4	1,812	1,682
Men's Clothing	27	2,329	2,319
Women's Clothing	36	2,011	1,974
Cotton Goods	47	21,161	20,127
Dyeing & Finishing	8	5,806	5,751
Hosiery & Knit Goods	15	4,278	4,271
Silk Goods	7	1,912	1,903
Textile Machinery	12	3,846	3,643
Woolen & Worsted Goods	50	11,026	10,444

Reference: Massachusetts Dept. of Labor and Industries. Monthly Survey March 1932 P. 3

III. THE TARIFF AND THE TEXTILE INDUSTRY.

The question of tariff has always been of vital importance in connection with the textile industry. It was thought by many that the tax on imports should be high in order to safeguard American manufacture. In the address by Mr. Search in 1895 he spoke of the futility of high tariff if American goods were inferior to European products. He referred to the fact that America imported $100,000,000 worth of goods in spite of high tariff. He said, "We must have a tariff not only in dollars and cents to cover our labor but we must also have that protection which springs from the cultivation of our powers and which leads to happy and elegant expression of our thought in line and color."

The tariff question is still important. Since we use about a third more wool than is grown in the United States, it is necessary to import a part of the wool. There is a tax of 34 cents a pound clean weight on all clothing wool imported into this country. There has been much debating as to the meaning of "clean content." The following article appeared in the Boston Evening Transcript, March 3, 1932:

Reference: Search, Theodore C.
Textile Education in America P. 7

"The wool trade is still awaiting news from Washington regarding the recent protest to Assistant Secretary of the Treasury Lowman on the 'Clean Content' ruling made by the Commissioner of Customs F.X.A.Eble, as of February 8. At that time Mr. Eble instructed wool appraisers at the several ports of entry that for purposes of assessing duties,'clean content' is not carbonized wool but wool that has been thoroughly scoured with a gain of 13 3/4 per cent."

In June of last year the Bureau of Customs gave several hearings on the Classification of Wool and there developed a general uniformity of opinion as to the meaning of "Clean Content" as signifying wool free from all foreign matters such as sand, grease, dirt, and vegetable matter and in normal condition as to moisture. The wool trade was unaware of any change of meaning until instructions were given to appraise wool for duty purposes on a scoured basis rather than on "Clean Content". It was argued that importers ought not to be required to pay 34 cents a pound on burrs and other vegetable matter left in wool after this process of scouring.

Reference: Boston Evening Transcript March 3, 1932
P. 22

As an illustration of tariff act as it effects the textile industry the Tariff Act of 1930 as it effects the woolen manufacture is given. The duty on wool and various manufactured articles call for following facts in arithmetic:

Addition

Multiplication

Percentage

U.S. Money

Yarn Counts

The Tariff as it effects the wool industry is outlined as follows:

Tariff Act of 1930

Schedule II. Wool and Manufactures of

Par. 1101. (a) Wools: Donskoi, Smynna, Cordova, Syrian, Aleppo, Georgian, Turkestan, Arabian, Bagdad, Persian, Sistan, East Indian, Thibetan, Chinese, Manchurian, Mongolian, Egyptian, Sudan, Cyprus, Sardinian, Pyrenean, Oporto, Iceland, Scotch Blackface, Black Spanish, Kerry, Haslock, and Welch Mountain; similar wools without merino or English blood; all other wools of whatever blood or origin not finer than 40S; and hair of the Camel; all the foregoing in the grease or washed, 24 cents per pound of clean content; scoured 27 cents per pound of clean content: on the skin 22 cents per pound of clean

content; sorted, or matchings, if not scoured, 25 cents per pound of clean content: Provided, that a tolerance of not more than 10 per centum of wools not finer than 44S may be allowed in each bale or package of wools imported as not finer than 44S; Provided further, that all the foregoing may be imported under bond in an amount to be fixed by the Secretary of the Treasury and under such regulation as he shall prescribe; and if within three years from the date of importation or withdrawal from bonded store houses satisfactory proof is furnished that the wools or hair have been used in the manufacture of press cloth, camel's hair belting, rugs, carpets, or any floor covering, or in the manufacture of knit or felt boots or heavy fulled lumbermen's socks, the duties shall be remitted or refunded:

And provided further, that if any such wools or hair imported under bond as above prescribed are used in the manufacture of articles other than press cloth, camel's hair belting, rugs, carpets, or any other floor coverings, or knit or felt boots or heavy fulled lumbermen's socks, there shall be levied, collected, and paid on any such wools or hair so used in violation of the bond, and in

addition to the regular duties provided by paragraph, 50 cents per pound, which shall not be remitted or refunded on exportation of the articles or for any other reasons.

(b) For the purposes of this schedule:

(1) Wools and hair in the grease shall be considered such as are in their natural condition as shorn from the animal, and not cleansed otherwise than by shaking, willowing, or burr-picking;

(2) Washed wools and hair shall be considered such as have been washed, with water only, on the animal's back or on the skin, and all wool and hair not scoured, with a higher clean yield than 77 per centum shall be considered as washed;

(3) Scoured wools and hair shall be considered such as have been otherwise cleansed (not including shaking, willowing, burr-picking, or carbonizing);

(4) Sorted wools or hair, or matchings, shall be wools and hair (other than skirtings) wherein the identity of individual fleeces has been destroyed, except that skirted fleeces shall not be considered sorted wools or hair, or matchings, unless the backs have been removed; and

(5) the Official Standards of the United States for grades of wool as established by the Secretary of Agriculture on June 18, 1926, pursuant

to law, shall be standards for determining the grade of wools.

Par. 1102 (a) Wools, not specially provided for, not finer than 44S, in the grease or washed, 29 cents per pound of clean content; scoured, 32 cents per pound of clean content; on the skin, 27 cents per pound of clean content; sorted, or matchings, if not scoured, 30 cents per pound of clean content; Provided, that a tolerance of not more than 10 per centum of wools not finer than 46S may be allowed in each bale or package of wools imported as not finer than 44S.

(b) Wools, not specially provided for, and hair of the Angora goat, Cashmere goat, alpaca, and other like animals, in the grease or washed, 34 cents per pound of clean content; scoured, 37 cents per pound of clean content; on the skin, 32 cents per pound of clean content; sorted, or matchings, if not scoured, 35 cents per pound of clean content.

Par. 1103. If any bale or package contains wools, hairs, wool wastes, or wool waste material, subject to different rates of duty, the highest rate applicable to any part shall apply to the entire contents of such bale or package, except as provided in paragraphs 1101 and 1102.

Par. 1104. The Secretary of the Treasury is hereby authorized and directed to prescribe methods and regulations for carrying out the provisions of this schedule relating to the duties on wool and hair. The Secretary of the Treasury is further authorized and directed to procure from the Secretary of Agriculture, and deposit in such custom houses and other places in the United States, or elsewhere, numbered, but not otherwise identifiable, samples of imported wool and hair, to which are attached data as to clean content and other pertinent facts for the information of the trade and of customs officers.

Par. 1105 (a) Top waste, slubbing waste, roving waste, and ring waste, 37 cents per pound: garnetted waste, 26 cents per pound; noils, carbonized, 30 cents per pound, noils not carbonized, 23 cents per pound; thread or yarn waste 25 cents per pound; card or burr waste, carbonized, 23 cents per pound; not carbonized 16 cents per pound; all other wool wastes not specially provided for 24 cents per pound; shoddy, and wool extract 24 cents per pound; mungo, 10 cents per pound; wool rags, 18 cents per pound; flocks, 8 cents per pound.

(b) Wastes of the hair of the Angora goat, Cashmere goat, alpaca, and other like animals shall be dutiable at the rates provided for similar types of wool wastes.

Par. 1106. Wool and hair of the kinds provided for in this schedule, if carbonized, or advanced in any manner or by any process of manufacture beyond the washed or scoured condition, including tops, but not further advanced than roving, 37 cents per pound and 20 per centum ad valorem.

Par. 1107. Yarn, wholly or in chief value of wool, valued at not more than $1. per pound, 40 cents per pound and 35 per centum ad valorem; valued at more than $1. but not more than $1.50 per pound, 40 cents per pound and 45 per centum ad valoren; valued at more than $1.50 per pound, 40 cents per pound and 50 per centum ad valorem.

Par. 1108. Woven fabrics, weighing not more than four ounces per square yard, wholly or in chief value of wool valued at not more than $1.25 per pound, 50 cents per pound and 50 per centum ad valorem; valued at more than $1.25 but not more than $2. per pound, 50 cents per pound and 55 per centum ad valorem; valued at more than $2. per pound, 50 cents per pound and 60 per centum ad valorem; Provided, that if the

warp of any of the foregoing is wholly of cotton, or other vegetable fiber, the duty on the fabric, valued at not more than $1. per pound shall be 40 cents per pound and 50 per centum ad valorem; valued at more than $1. but not more than $1.50 per pound, 40 cents and 55 per centum ad valorem; valued at more than $1.50 per pound, 40 cents per pound and 60 per centum ad valorem.

Par. 1109. (a) Woven fabrics, weighing more than four ounces per square yard, wholly or in chief value of wool, valued at not more than $1.25 per pound, 50 cents per pound and 50 per centum ad valorem; valued at more than $1.25 but not more than $2. per pound, 50 cents per pound and 55 per centum ad valorem; valued at more than $2. per pound, 50 cents per pound and 60 per centum ad valorem.

(b) Felts, belts, blankets, jackets, or other articles of machine clothing, for paper making, printing, or other machines, when woven, wholly or in chief value of wool, as units or in the piece, finished or unfinished, shall be dutiable at the rates provided in subparagraph (a).

Par. 1110. Pile fabrics, whether or not the pile covers the entire surface, wholly or in chief value of wool, and all articles, finished or unfin-

ished, made or cut from such pile fabrics; If the pile is wholly cut or wholly uncut, 44 cents per pound and 50 per centum ad valorem; if the pile is partly cut, 44 cents per pound and 55 per centum ad valorem.

Par. 1111. Blankets, and similar articles (including carriage and automobile robes and steamer rugs), made of blanketing, as units or in the piece, finished or unfinished, wholly or in chief value of wool, not exceeding three yards in length, valued at not more than $1. per pound, 30 cents per pound and 36 per centum ad valorem; valued at more than $1. but not more than $1.50 per pound, 33 cents per pound and 37 1/2 per centum ad valorem; valued at more than $1.50 per pound, 40 cents per pound and 40 per centum ad valorem; Provided, that on all the foregoing, exceeding three yards in length, the same duty shall be paid as on woven fabrics of wool weighing more than four ounces per square yard.

Par. 1112. Felts, not woven, wholly or in chief value of wool, valued at not more than $1.50 per pound, 30 cents per pound and 35 per centum ad valorem; valued at more than $1.50 per pound, 40 cents per pound and 40 per centum ad valorem.

Par. 1113. Fabrics, with fast edges, not exceed-

ing twelve inches in width, and articles made therefrom; tubings, garters, suspenders, braces, cords, and cords and tassels; all the foregoing, wholly or in chief value of wool, 50 cents per pound and 50 per centum ad valorem.

Par. 1114. (a) Knit fabric, in the piece, wholly or in chief value of wool, valued at not more than $1. per pound, 33 cents per pound and 40 per centum ad valorem; valued at more than $1. per pound, 50 cents per pound and 50 per centum ad valorem.

(b) Hose, half-hose, gloves, and mittens, finished or unfinished, wholly or in chief value of wool, valued at not more than $1.75 per dozen pairs, 40 cents per pound and 35 per centum ad valorem; valued at more than $1.75 per dozen pairs, 50 cents per pound and 50 per centum ad valorem.

(c) Knit underwear, finished or unfinished, wholly or in chief value of wool, and not specially provided for, valued at not more than $1.75 per pound, 40 cents per pound and 30 per centum ad valorem; valued at more than $1.75 per pound, 50 cents per pound and 50 per centum ad valorem.

(d) Outerwear and articles of all kinds, knit or crocheted, finished or unfinished, wholly or in chief value of wool, and not specially

provided for, valued at not more than $2. per pound, 44 cents per pound and 45 per centum ad valorem; valued at more than $2. per pound, 50 per centum ad valorem.

Par. 1115. (a) Clothing and articles of wearing apparel of every description, not knit or crocheted, manufactured wholly or in part, wholly or in chief value of wool, valued at not more than $4. per pound, 33 cents per pound and 45 per centum ad valorem; valued at more than $4. per pound, 50 cents per pound and 50 per centum ad valorem.

(b) Bodies, hoods, and shapes, for hats, bonnets, caps, berets, and similar articles manufactured wholly or in part of wool felt, 40 cents per pound and 75 per centum ad valorem; and, in addition thereto, on all the foregoing, if pulled, stamped, blocked, or trimmed (including finished hats, bonnets, caps, berets, and similar articles), 25 cents per article.

Par. 1116. (a) Oriental, Axminster, Savonnerie, Aubusson, and other carpets, rugs, and mats, not made on a power-driven loom, plain or figured, whether woven as separate carpets, rugs, or mats or in rolls of any width, 50 cents per square foot, but

not less than 45 per centum ad valorem.

(b) Carpets, rugs and mats of oriental weave or weaves, made on a power-driven loom; chenille Axminster carpets, rugs, and mats; all the foregoing, plain or figured whether woven as separate carpets, rugs, or mats, or in rolls of any width, 60 per centum ad valorem.

Par. 1117. (a) Axminster carpets, rugs, and mats, not specially provided for; Wilton carpets, rugs and mats; Brussels carpets, rugs and mats; Velvet or tapestry carpets, rugs, and mats; and carpets, rugs, and mats of like character or description; all the foregoing, valued at not more than 40 cents per square foot, 60 per centum ad valorem.

(b) Ingrain carpets, mats, and rugs or art squares, of whatever material composed, and carpets, rugs, and mats, of like character or description, not specially provided for, 25 per centum ad valorem.

(c) All other floor coverings, including mats and druggets, wholly or in chief value of wool, not specially provided for, valued at not more than 40 cents per square foot, 30 per centum ad valorem; valued at more than 40 cents per square foot, 60 per centum ad valorem.

(d) Parts of any of the foregoing shall be dutiable at the rate provided for the completed article.

Par. 1118. Screens, hassocks, and all other articles, composed wholly or in part of carpets, rugs, or mats, and not specially provided for, 30 per centum ad valorem.

Par. 1119. Tapestries and upholstery goods (not including pile fabrics), in the piece or otherwise, wholly or in chief value of wool, shall be subject to the applicable rates of duty imposed upon woven fabrics of wool in paragraph 1108 or 1109.

Par. 1120. All manufactures, wholly or in chief value of wool, not specially provided for, 50 per centum ad valorem.

Par. 1121. Whenever in this title the word "wool" is used in connection with a manufactured article of which it is a component material, it shall be held to include wool or hair of the sheep, camel, Angora goat, Cashmere goat, alpaca, or other like animals, whether manufactured by woolen, worsted, felt or any other process.

Par. 1122. Fabrics (except printing machine cylinder lapping in chief value of flax), in the piece or otherwise containing 17 per centum or more in weight of wool, but not in chief value thereof, and

whether or not more specifically provided for, shall be dutiable as follows:

That proportion of the amount of the duty on the fabric, computed under this schedule which the amount of wool bears to the entire weight, plus the proportion of the amount of the duty on the fabric, computed as if this paragraph had not been enacted, which the weight of the component materials other than wool bears to the entire weight.

The unit of measure used in estimating tariff is the pound.

The processes of arithmetic involved are addition, multiplication, percentage, United States money and yarn counts.

IV. THE SCOPE OF THE INDUSTRY.

The word textile is used to indicate materials which have been spun or woven or resemble spun or woven materials.

Textiles are divided according to origin as follows:

1. Animal fibers
    a. silk
    b. wool
    c. various kinds of hair
2. Vegetable
    a. cotton
    b. linen
    c. jute
    d. hemp
    e. rope fibers
3. Mineral
    a. asbestos
4. Artificial fibers
    a. various kinds of artificial silk.

Since New England is noted especially for the manufacture of woolen and worsted goods we shall discuss that phase of the industry more in detail.

The great clothing wool producing countries of the world are Australia, South America,

the United States and South Africa. According to figures received from Mr. F. Nathaniel Perkins, Secretary of Boston Wool Association, the world's production for 1931 was 3,640,000, 000 pounds and the production for the United States was 397,000,000 pounds.

Australia is reputed to be the largest producer of the best wool, that is, wool with the finest fiber. Yet much of the wool from Ohio, Pennsylvania, and West Virginia is of very fine quality. Since 1922 Texas has led the states in the production od fleece wool. The following table indicates the states leading in the production of wool.

FLEECE WOOL PRODUCTION BY LEADING STATES

In thousands of pounds.

State	1924	1925	1926	1927	1928	1929	1930
United States	235,575	245,562	260,976	281,914	303,715	310,561	336,007
Texas	24,806	25,280	27,297	32,725	38,200	41,300	41,600
Montana	19,522	20,640	23,320	24,166	26,626	28,733	33,440
Wyoming	19,090	21,362	22,338	25,317	26,488	26,000	30,360
California	18,250	19,912	20,276	23,800	23,800	25,636	27,001
Utah	17,970	18,010	19,430	19,975	22,072	19,011	21,600
Oregon	15,840	16,958	18,321	18,128	20,336	18,849	21,375
Idaho	14,450	14,309	14,507	15,840	17,885	17,829	18,768
New Mexico	11,224	11,084	12,060	12,600	13,683	14,600	16,167
Ohio	14,167	14,467	14,760	15,662	14,776	14,426	15,066
All Others	80,256	83,540	88,667	93,701	99,853	104,177	110,630

1930- Figures are preliminary and subject to revision

Reference; Commerce Year Book 1931

Vol. I,Page 486, Table 17

In United States wool is grown mostly on ranches in Texas, Montana, Wyoming, California, Oregon, New Mexico and other states. Farmers shear their sheep once a year. The sheep are shorn by power shears rather than by hand. Shearing commences in Arizona in February or March, and the latest state to shear is Montana where shearing is not completed until July 4th. In a recent issue of the Boston Evening Transcript occured the following news item;

"Boise, Idaho, March 3 - Woolies have begun to doff their fleeces on Idaho sheep ranges. Bands are now being sheared at Grandview, on the Snake River, 15,900 head having been clipped in part already. Contracts are being negotiated for 50,000 head south of Caldwell and 80,000 head near Mountain Home, Idaho, according to M. C. Claar, secretary of the Idaho Wool Growers Association.

Shearing prices are below those last year. John Archibald, for example, one of the State's biggest flock masters, has contracted to have 40,000 of his flee ced at eight cents and board per head, or fourteen cents and the shearers furnish everything. Last year shearing prices were nine cents a head with board or seventeen cents a head all furnished. The price Archibald is paying,

moreover, is said to involve one cent premium because his flocks are scattered. Discussion of seven cents a head with board and thirteen cents all furnished has been reported."

These ranch wools are generally congregated at some railroad station and are bid on by buyers from various sections of the country.

The sheep in ranch countries run in bands of 2500 sheep. A herder with the aid of a dog tends the flock. Sheep men are subjected to great losses of sheep during storms in winter season. Often during these storms the sheep are forced to go without food for long periods of time. The deprivation invariably causes weakness in the fiber of the wool. The section of wool in process of growth at this period shows the effect of lack of nourishment.

One of the reasons why wool is so well adapted to manufacturing purposes is on account of warp wearing qualities. If you place a fiber under the microscope you will observe that the fiber is filled with little scales or sacques which give felting qualities lacking in cotton fibers.

While 400,000,000 pounds of wool are

Reference: Boston Evening Transcript March 3, 1932.

produced in United States, this country consumes about 600,000,000 pounds. This means that 200,000,000 pounds have to be purchased abroad.

Carpets are made from coarse wools. Practically all carpet wools come from Asiatic countries.

Some sheep are slain for food and the pelts from these sheep have wool pulled. From 50,000,000 to 60,000,000 pounds of pulled wool are purchased in the United States yearly.

1931 was a banner year in the wool industry in the United States. For the first time in its history the wool clip was over 400,000,000 pounds. This record clip is not due to increased number of sheep but rather improved methods of breeding. The westward movement of sheep bands is responsible for the improved practices in sheep breeding. New England as in many enterprises gets credit for beginning commercial production of wool in this country. In early days Vermont and New Hampshire were centers of wool production. Gradually the center moved westward so that by 1840 the center was Pennsylvania and by 1850 Indiana. The geographical center in 1920 was somewhere in Nebraska. Two factors worked toward this end; settlement of more valuable land by home seekers and prospect of free grazing lands in the west.

As the available ranges became more limited, it became necessary to decrease the production of sheep and at the same time meet the growing needs for increased wool supply. According to the census report the high of all time in respect to sheep population came in 1903 when it was estimated that the sheep population was approximately 53,000,000 head, about 1,000,000 more than government estimate at beginning of 1931. The census report lists 63,964,576 as total for all sheep for 1903. The wool production for 1903 was only 287,450,000 pounds, 245,000,000 pounds representing shorn wool and 42,000,000 pounds representing pulled wool. The average per fleece for 1903 was 6.25 pounds.

Compare the record of 1903, the year of higher sheep population, with 1931, the year of record clip. The estimated sheep population for 1931, according to the department of Agriculture, was 51,911,000. It is reported that 47,331,000 sheep were shorn, and that the average per fleece was 7.8 pounds or total of 367,655,000 pounds. The pulled wool production for 1931 was estimated at 60,000,000 pounds, which made total wool production for year 427,655,000 pounds. The average for past thirty-five years has been approximately 300,000,000.

Reference: Fitzgerald, "Century of Progress in Sheep Breeding."

The significance of the improved method in sheep industry is shown by the following statistical account given in Boston Evening Transcript January 21, 1932 by O. A. Fitzgerald.

"From 1840 to 1900 the average fleece herd increased to nearly 5.5 pounds and by 1903, the year the nation reported maximum sheep numbers, it was 6.25 pounds. Today the average production for the country is close to eight pounds, being 7.8 pounds for the 1931 clip. Today the average sheep grows enough wool for one suit of men's clothing. In the principal wool states of the Far West, which produce the bulk of domestic wool, however, the average for several years has exceeded 8 pounds per fleece.

For the 1931 clip, the average of the eleven far western states, which with Texas and Ohio are the leading wool producers, was 8.3 pounds. The states in this group and their averages follow; Arizona, 6 pounds; California, 7.3 pounds; Idaho, 9.2 pounds; Montana, 9.2 pounds, Nevada, 7.8 pounds; New Mexico, 6.4 pounds; Oregon, 9 pounds; Utah, 8.8 pounds; Wyoming, 9.6 pounds; Washington, 9.5 pounds. It should be noted that five of these states had averages of nine pounds or better per fleece."

Reference; "Century of Progress in Sheep Raising."
O. A. Fitzgerald.

Mr. Fitzgerald in the same article, "Century of Progress in Sheep Breeding" gives figures to show the tendency to decidedly reduce the sheep population. He says, "In 1867, Ohio had 7,159,000 sheep. The decline between 1910 and 1917 was 24 percent. Today Ohio's sheep population has become fairly well fixed; the adjustment has been made. Its present number is slightly over 2,000,000.

Montana and California have had similar experiences. In 1902 Montana had 8,932,999 sheep, approximately twice as many as today. The decline, due to land settlement and competition with cattle interests, was to 2,791,000 in 1920. Montana's sheep population the first of 1931 was 4,326,000. In 1884 California had 7,646,800 sheep. In 1920 the sheep population of the State was 2,972,000, at the beginning of 1931 its count was 4,119,000 head. Texas and California figured very prominently in the sheep expansion immediately following 1860.

It is now estimated that in 1860 the Far West's total sheep population numbered only 3,999,000 head, mostly in Texas, New Mexico and California. Ten years later, 1870, the number had doubled and the trend involved a heavy movement of sheep bands into the northern range country. By 1880 far western sheep bands had increased to 18,000,000 head and by

1885 had reached a high point of 26,000,000 head. Settlement of the more desirable lands of the west and competition with cattle industry resulted in the decline of sheep numbers."

After 1885 the sheep industry was forced to change from its nomadic ways and became more permanent in its habitat, hence there was the need to make fewer sheep produce more wool. The question of expenses brought the realization that the cost of feeding, caring for and shearing a ewe which produced 3 or 5 pounds was as great as for one which produced from 8 to 10 pounds. On the other hand the material gain from the greater production per fleece was quite an item. The wool clip has shown a steady improvement for the past eight years both in production and in quality. So far as the textile industry is concerned wool is not just "wool", but has to meet the demands of the trade. There has been much experimentation in crossing breeds of sheep and bringing in new breeds from other countries. It is estimated that there are approximately two hundred breeds of sheep in the world, many of which are entirely unknown in this country. The yearly ram sales in the west have done much to stimulate interest in improving sheep industry. These sales are important from

educational standpoint. Prices from $500 to $1500 are common, but as much as $5200 has been paid for a prize ram. Madsen's Monarch, the son of "I Am" the $2,000 ram lamb of the Western ram sale, won grand championship at Pacific International Livestock Exposition at Portland, Oregon in 1930 when he was only a year old.

The ranch wools are generally congregated at some railroad station and wools are there bid on by buyers from various parts of the country. Doubtless some of these buyers are from Boston because of the very large number of wool houses on Summer Street just across from Fort Point Channel. Mr. William A Febiger, former president of Boston Wool Trade Association, said, "When I first cam to Boston in 1910-11, Summer Street was known as the "Wool Canyon!." This same district still handles a tremendous percentage of the wool clip of the country, and a good share of the Foreign Staple imported, of which the greater part is consumed in New England.

The fleece is removed, tied up and shipped in bags or bales averaging from 100 to 500 pounds each. According to an article in the Boston Evening Transcript for March 3, 1932, there has been a re-

Reference: Boston Evening Transcript January 21, 1932.

vision of figures giving wool production for 1931.

"Another revision of the wool production figures for the country at large has been given out by the Department of Agriculture, but it is not taken in the trade that this is by any means final. The current estimate involves a revision upward from the preliminary figures. As now estimated the production of shorn wool for 1931 was 369,315,000 pounds as compared with 351,521,000 pounds in 1930, and 327,566,000 pounds in 1929. The revision for 1931 adds 1,660,000 pounds to the preliminary estimate. It is perhaps too much to expect a closer relationship between preliminary and revised estimates. It is also understood that at best these estimates are arbitrarily based upon certain reports compiled by various Government agencies. What seems remarkable, and which has attracted attention in the trade, is that almost uniformily the revisions made for several years have been in an upward direction.

In some cases the changes have run into millions of pounds and have been of sufficient moment to be a disturbing factor in the local wool market. While the difference of 1,660,000 pounds for 1931 is not so large as often found before, there is another

Reference: Boston Evening Transcript March 3, 1932.

and more disturbing angle. To the production of 369,315,000 pounds of shorn wool must be added 66,100,000 pounds of pulled wool, itself an increase for 1931 over 1930 of 4,200,000 pounds. Thus it appears that the total of domestic wool available from 1931 production was 5,860,000 pounds larger than that of 1930.

"The only offset to this is that the mills reporting to the Department of Commerce increased consumption of more than 82,000,000 pounds, the comparative figures being 377,789,673 pounds in 1930 and 459,812,985 pounds in 1931. Here again caution is needed in the use of the figures, to avoid error and confusion. Of the total consumption noted above, only 319,746,254 pounds was domestic wool. If to this is added 25 percent, which is believed to be a fair allowance for consumption by mills not reporting to the Department of Commerce, the total estimated consumption in 1931 by American mills is 399,682,817 pounds, approximately 22 percent increase over 1930 figures. This increased consumption has justly been regarded as one of the most encouraging features of the present wool textile situation."

As has been mentioned before much of the wool clip reaches Boston. The classified Telephone

Directory for Boston and vicinity for 1931-1932 reports 15 wool brokers, 168 wool dealers, six wool scouring companies, 25 wool stock dealers, 4 wool substitute business houses, 40 wool waste dealers, 55 woolen goods business places. The classified Business Directory for New England (1929) reports 147 woolen and worsted manufacturing plants for Massachusetts alone. In this list there are several different plants operated by a single company, for example, American Woolen Company.

A walk down Summer Street, Boston, would give opportunity to note the variety of foreign and domestic wools used in the industry. This is evidenced by the terms mohair, cashmere, camel's hair, noils, tops, alpaca, pulled wool, grease wool, scoured wool. In talking to the managers in several of these houses, I learned that the wool was purchased in bags or bales ranging from 200 to 400 pounds. This wool is purchased on basis of so much per pound and is sold on same basis, i. e. by the pound.

The manufacturers buy wool either graded or in the original package. If wool is bought in the grease the price may be 16 cents while price for clean content will be 33 cents, allowing for 50 percent shrinkage. Wools vary in price from 15 to 25 cents per pound. Since we use about a third

more wool than is grown in United States, it is necessary to import a part of wool. There is a tax of 34 cents a pound clean weight on all clothing wool imported into this country.

In discussing the scope of the industry the following arithmetical processes were encountered:

Reading numbers
Cost of shearing
Decimals
Averages
United States money
Percentage
Specific duty

V. THE STORY OF MAKING WOOL INTO CLOTH.

The wool fleece finally reaches the manufacturing plants and the process of making it into cloth is explained in a bulletin entitled "From Wool to Cloth" published by the American Woolen Company.

The story is as follows:

"When the fleece is removed from the sheep by a skillful shearer, the wool sticks together, and the whole fleece may be spread out like the skin of the animal. Each fleece is tied up separately, and the wool is shipped in bags or bales, containing from one hundred to five hundred pounds each.

When the wool is received at the factory it is in fleeces, and each fleece contains different kinds of fibers - long and short - coarse and fine, and it is necessary that these should be sorted into different kinds or grades, as may be desired - perhaps six or eight different kinds, according to the particular uses to which the different qualities are to be put.

The fleece is spread out on a table, the center of which is covered with wire netting, and through this netting part of the dust and other matter from the wool falls while the sorting is

going on. Sorters tear with the hands the different parts of the fleece from each other and separate them into piles, according to their different qualities.

All unwashed wool contains a fatty or greasy matter called yolk, which is a secretion from the skin of the sheep. The effect of this yolk is to prevent the fibers of the wool from matting, except at the ends, where, of course, it collects dust, and forming a sort of a coating, really serves as a protection to the rest of the fleece while on the sheep's back.

After the wool is sorted it is next cleansed or scoured, in order to remove all this yolk, dirt and foreign matter, and this is accomplished by passing the wool, by means of automatic rakes, through a washing machine, consisting of a set of three or four vats or bowls, which contain a cleansing solution of warm, soapy water, until all the grease and dirt have been removed.

Each bowl has its set of rollers, which squeezes out the water from the wool before it passes into the next bowl. Having passed through the last bowl and set of rollers, the wool is carried on an apron made of slats on chains, to

the drying chamber, called the dryer, where is taken out most of the moisture.

The wool is now blown through pipes or carried on trucks to the carding room.

From this point the wool follows one of two different processes of manufacture - that of making into worsteds, or that of making into woolens.

Speaking in a general way, worsted fabrics are made of yarns in which the fibers all lie parallel, and woolens are made of yarns in which the fibers cross or are mixed. Ordinarily, worsteds are made from long staple wools and woolens from short staple wools.

WORSTEDS

The next process in the manufacture of worsteds is carding. In this process the wool is passed between cylinders and rollers, from which project the ends of many small wires. These cylinders revolve in opposite directions. The result is the opening, separating and straightening of the fibers; and the wool is delivered in soft strands, which are taken off by the doffer comb and wound upon a wooden roll into the shape of a large ball, known as the card ball or card-sliver, or put into a revolving can. The sliver

from a number of these balls or cans is now taken and put through what is known as the gilling machine, which to a degree straightens the fibers.

From the gilling machine the wool comes off in soft strands. Four strands are then taken to the balling machine where is made a large ball, ready for the combing. It takes eighteen of these balls to make a set or fill up the comb.

By means of the comb the fiber is still further straightened out, the short stock and noil, or nibs, are removed, and when the sliver comes from the combs most of the fibers are parallel to each other. A number of the slivers taken from the comb are then put through two further operations of gilling, and wound into a large ball, which is called a finished top.

The dyeing is done in three ways - in the top, in the thread or skein after being spun, or in the piece after it is woven. If the wool is to be stock dyed - that is, dyed in the top - it is sent to the dyehouse to be dyed the shade required, and afterwards returned to be gilled and recombed ready for the drawing.

Up to this point there has been no twist given to the wool, not any appearance of a thread. The top, the soft untwisted end, is now run through

the drawing machine, the process sometimes consisting of nine distinct operations, and is drawn and redrawn until reduced to the size required for its special purpose; and the stock is then delivered to the spinning room on spools, and is called roving.

In the spinning the process of drawing continues until the twisted thread is reduced to the size required, which either singly or twisted together in two, three or four strands, is to be used for weaving.

The yarn is then very carefully inspected, and all imperfections which would show in the finished goods are removed, and if it is to be dyed in the skein, the yarn is taken to a reel, where the skeins are made ready for the dyehouse.

The threads must now be prepared for the loom in order that the actual weaving may be done. The thread is used in two ways in weaving - as warp, which is the thread which runs lengthwise of the cloth, and as filling, or woof, which runs across the cloth from side to side.

The warp threads - the threads which run lengthwise of the cloth - are sized and wound upon large reels, and from these transferred to a large wooden roll called the warp, which holds all the warp threads, usually several thousand.

The filling threads are put on shuttle bobbins and placed in the shuttles to be refilled by the operatives as required, and as the weaving progresses.

The warp beam is then taken to the drawing room, where these several thousand threads are drawn through wire heddles in a frame called the harness, then drawn through a wire reed. The completed warp beam is now ready for the loom.

The harnesses are placed in the loom, and by means of what is called the "head motion" part of the threads are raised and part are lowered. This allows the filling shuttles to pass above some threads and below others, filling out the pattern required.

The cloth, having been made in such length as is desired is taken from the loom, and by what is known as burling and mending, any knots or threads woven in wrongly are removed, and any imperfections which have been discovered through a careful examination are corrected.

The web of cloth is scoured or washed and any foreign matter removed.

Undressed fabrics would now be fulled. This consists of running cloth through a fulling machine where, moistened with a specially prepared

soap, it is subjected to a great pressure and pounding, which aids in giving the required finish.

There are different kinds of finishes which require different treatments and it would be impracticable for us to dwell in detail upon this matter here.

If dyed in the piece, the web or cloth is taken to the dyehouse and dyed. It is thoroughly rinsed, all moisture is extracted from it and it is dried.

After drying, the cloth is run through a machine by which is brushed and sheared, the brushing lifting the long fibers and the shearing cutting them off at even length. The cloth is put through the press, which irons it out, giving it the lustre or finish that is desired. It is examined again for further imperfections, and if such have occurred they are corrected.

Measuring, weighing, rolling and tagging follow, and the cloth is packed and ready for the market.

WOOLENS

Woolens are made from short staple wools, known as clothing wools, and in the finished woolens the fibers of the yarn cross or are mingled together.

In the case of woolens, after the scouring, it is frequently necessary to remove burrs or other vegetable matters from the wool. To accomplish this the wool is dipped in a bath of chloride of aluminum or sulphuric acid solution, then the moisture is extracted and the wool is put through a drier, where the temperature must be at least 212 degrees. This heat carbonizes the foreign substance, but has little effect on the animal fibers of the wool.

Next, an ingenious machine called the burr picker removes the burr.

Sometimes there is to be a blend of the wool with other stocks, and in that case the several different wools are mixed together.

Dyeing of woolens is done in three ways - in the wool, in the thread after it is spun or in the piece after it is woven. If the wool is to be "dyed in the wool" it is now conveyed to the dye-house, dyed the shade required, then returned to the mixing room.

During the process of scouring, when the yolk was removed, a large part of the natural oil of the wool was also eliminated, and in order to restore this lubricant, the wool is sprinkled with an oil emulsion, and the mixing picker thoroughly

blends the wools.

From here the wool goes to the card room, and by means of the carding machine the fibers are carded and drawn and delivered to the finisher in a broad, flat sheet, By means of the condenser it is divided into narrow bands, and the wool-free as yet from twist - comes out in soft strands. These strands or threads are called roping.

Now comes the mule spinning. The roping passes through rolls by which it is drawn and twisted to the size required, and wound on paper cap tubes or bobbins. Such of the yarn as is to be used for warp is then spooled from the bobbins to dresser spools. It is sized and wound upon large reels, from there transferred to the warp beam, as in the case of worsteds.

The processes of drawing-in, preparation for weaving, burling and mending are practically the same as in the cause of worsteds.

The finishing processes of woolens, like the finishing processes of worsteds vary with different fabrics, some fabrics being scoured and cleansed in the washers before fulling, others going to the fulling mill without cleansing. After fulling, the cloth is again washed and rinsed, and if necessary to remove any vegetable fibers, it is carbonized.

Napping or gigging raises the fibers to the nap desired. Gigging is done by means of a wire napping machine or teasel gig, which raises the ends of the fibers on the face of the cloth. The teasel is a vegetable product about the shape of a pine cone, and it is interesting to note that no mechanical contrivance has ever been invented to equal it for the purpose.

The napping which has been raised by the teasel is sheared or cut to a proper length by machine. The cloth is pressed, and, if it is desired to finish it with lustre, it is wound upon copper cylinders and steam is forced through it at a high pressure.

Next the cloth is dyed, if it is to be piece-dyed - that is, dyed in the piece.

If the cloth is a mixture the wool was dyed immediately after the scouring. In worsteds the dyeing is done either just after it has been subjected to the first combing processes, or the yarn is dyed in the skein or hank.

In the dry finishing the cloth is finished with various kinds of finished desired, and it is steamed, brushed, sheared and pressed. Another examination for any imperfections or defects follows; and the cloth is measured, packed and

tagged and is ready for the market.

"The difference between worsteds and woolens is principally that in the threads or yarns from which worsteds are made the fibers of the wool lie parallel, one to another, being made from combed wool, from which the short fibers have been removed; and woolens are made from yarns in which the fibers cross and are matted and intermixed. When finished the effect of worsteds and woolens is materially different. Upon examination it will be found that the worsted thread resembles a wire in evenness, while the woolen thread is uneven and irregular.

"A worsted fabric when finished has a clear, bright, well defined pattern, seems close and firmly woven, and is of a pronounced dressy effect; while woolensare softer, they are more elastic, the colors are more blended, the threads are not so easily distinguishable and the general effect is duller."

Reference:"From Wool to Cloth" American Woolen Co.

VI. LOWELL TEXTILE SCHOOL

The question naturally arises, whether there is any place where definite instruction concerning textile industry may be obtained. There are several textile schools in Massachusetts and one of the leading schools in this field is the Lowell Textile Institute. On June 1, 1891 a movement was started to establish the Lowell Textile School but it was not opened for instruction until February 1, 1897. As result of "the anti-aid amendment to the Constitution and by Chapter 274, General Acts of 1918, the property was transferred on July 1, 1918, to the Commonwealth of Massachusetts."

The Lowell Textile Institute is fortunate in being located at Lowell often called the "Mother Textile City of America." It enjoys close association with every branch of the industry as carried on in the great Merrimack Valley textile district.

The school was established "for the purpose of instruction in the theory and practical art of textile and kindred branches of the industry."

The school was first conceived to meet a crisis in the leading industry of New England, and the objective has always been to meet the needs of the industry as new demands arise. The students become acquainted not only with the theory and

and science involved in the industry, but also the practical application to the various processes.

The Lowell Textile Institute has been highly rated by both Federal and State educational boards and has been placed in the class of the higher technological schools of the country.

"The site is a commanding one, consisting of about 15 acres at high elevation on the west bank of the Merrimack River. It extends to and overlooks the rapids of Pawtucket Falls, which was the first water power in America to be used on an extensive scale to operate power looms. It was contributed by Frederick Fanning Ayer, Esq.; of New York City, and the proprietors of the Lock's and Canals on the Merrimack River.

"The buildings are of modern mill construction adapted to educational uses and contain approximately 180,563 square feet."

The day classes are for those who have completed a standard four year course in high school or academy. The students in the day classes pursue courses leading to diploma in three years or degree in four years.

To meet the entrance requirements, "particular stress should be laid upon a thorough grounding in mathematics, including algebra, arithmetic

and plane geometry, as these form the basis upon which the work of this school rests. While solid geometry is not required at the present time, the student will find a knowledge of this subject very valuable in his subsequent work, and is strongly recommended to include this subject as one of his electives. A preliminary course in science including physics and chemistry, serves to prepare the student's mind for the higher branches of these subjects and their applications, but neither will be considered as the equivalent of the courses in these branches given in the Institute."

The following courses are offered:

Course I. Cotton Manufacture

Course II. Wool Manufacture

Course III. Textile Design

Course IV Chemistry and Textile Coloring

Course V. Textile Engineering (General Course)

Course VI. Textile Engineering

Cotton Option

Wool Option

Design Option

Sales Option

All courses are open to women but textile designing and decorative art appeal more strongly to their taste. Some take courses in chemistry, power weaving and finishing.

Reference: Textile Institute Bulletin, Feb. 1931

The work in mathematics in the textile engineering department includes plane trigonometry, logarithms and instructions in the use of the slide rule. Right and oblique triangles are solved by means of natural and logarithmic functions, and the various algebraic relations among the trigonometric functions, are proved and used in identities and equations. The following topics are also studied; Graphical and mathematical solution of quadratic and simultaneous equations, theory of equations, partial fractions, Naperian logarithms, equations of the straight line, equations of various curves, differentiation of algebraic functions; and applications of the derivative, derivaties and differentials, the circle, parabola, ellipse, hyperbola, indefinite integrals, summation by integration and application by integration, differentiation of transcendental functions, methods of integration, centers of gravity, moments of inertia, empirical formulas, and some graphic charts, areas, volumes, pressures.

"The evening classes are held for about twenty weeks of the year, and are for those who are unable to attend the day courses. These are similar to the day courses, but are aimed especially to meet the needs of students working during

the day in mills and shops. For entrance to these classes an applicant should have the equivalent of a grammar school education."

"The object of these courses is to give young men of ambition an opportunity to obtain instruction in all branches of science that are allied with their daily work. For example, one is employed as a weaver in a textile mill may obtain knowledge of the manufacture of yarn, the production of a design, and the methods of finishing a fabric, as well as the manner of its weaving or knitting. In like manner the dyer may augment his knowledge of the chemicals and materials he is daily handling. The engineer and machinist may acquire a knowledge of the mathematics, science of mechanics, electricity and drawing that underlie all the works of an engineer.

It is recognized that the interests of such students lie in a particular field of industry, and these courses are designed to bear directly upon the special line, and supplement, as far as possible, the practical work in which the student is engaged during the day."

Some of the topics treated in mathematics in Evening Classes are:

Elementary algebraic operations of

Addition	Linear equations
Subtraction	Radicals
Multiplication	Quadratic equations
Division	Logarithms
Factoring	Slide rule
Fractions	Trigonometry
Graphical representation	

Visitors are cordially received and shown through the school. This gives a clearer understanding of the scope of the textile industry.

VII. MEASURES USED IN TEXTILE INDUSTRY

It is interesting to find out what measures belong peculiarly to the textile industry.

"The weaver", says Mr. Dale, "works in a maze of measurements that include yarn numbers or yards per pound, threads of warp per inch, dents of reed per inch, width in inches, length in yards, picks of filling per inch."

"Thickness and volume of the material in the process are expressed by ratio between weight and length of the sliver or roving. This count indicates not only the length, diameter, volume, and weight by the material, but also the proportion between them. Yarn count is the keystone of the arch of textile weights and measures. It is the guide for all operations and the expression, not only of length diameter, volume, weight and their complex relations, but also a means of expressing the quality and length of fibers. Worsted wool is called 40S if it can be spun to 40 x 560 or 20400 yards per pound; 60S if 60 x 560 or 33,600 yards per pound. This method of designating wool is an established custom throughout the commercial and manufacturing world based on English yard-pound, meaning wool of a certain fineness, length of staple,

Reference: "Metric Failure in Textile Industry" By Samuel S. Dale.

curl and strength, to the wool grower, dealer, buyer or sorter. To the carder, spinner and practical manufacturer it means this and also means yarn of certain size, uniformity and strength measuring 33,600 yards per pound, and cloth of a certain texture and quality.

"Yarn count means a certain length per pound; the twist is measured by the turns per inch. Expressions 6, 8, 10, 18, 24 or 40 turns express not only so many turns per inch but certain degrees of hardness in yarn, ideas which are connected with certain effects in woven and finished fabrics.

"The yarn count or length per pound means a certain appearance of the yarn, a certain strength and elasticity; it tells what production should come from each machine and how much should be paid for spinning 100 pounds or hanks.

"Wide cloths in the United States are woven and sold as so many even inches wide. We have 36, 40, 44, 48, 50 and 56 inch goods. Cloth is made wider in the loom than it is when finished to allow for shrinkage. The width from loom is generally measured in inches and tenths of inches, for example 68.3 inches wide. The length is given in yards and fraction of yard.

The following methods are used for numbering spun yarn.

Country	Unit of Weight	Length
Spain	Quater unca	400 canes
France	Gramme	1,2,5,25,50,100,250 metres
Scotland	Pound	14,400 yards
England	Dram	80 yards
Germany	Gramme	420 or 840 yds.(English)
America	Grain	1,5,10,12,20,50,80 or 120 yds.

When yarn is woven into cloth the bulk of the fabric is indicated by the weight of an area of fixed dimensions usually the length of one yard and a width expressed in inches.

All English fixed weight systems of yarn numbering are based on the number of skeins or hanks in one pound. Hanks vary in length according to the material.

Woolen	1600 yards
Cotton	840 yards
Worsted	560 yards
Linen	300 yards

The weight is expressed either by ounces per yard or yards per pound. The width is given in inches and the length in yards. The smallest fraction used in giving length of goods from the loom is 1/4, while the smallest fraction used to

designate the length of finished goods is 1/8. Special scales record width of cloth in inches and tenths of inch and length in yards and eighths of a yard.

Cloth analysis is a very important operation and calls for great accuracy. A sample approximately four square inches is considered the most desirable size for analysis. If too small a slight error may cause serious defect in the cloth. By dividing the number of threads per inch by the weight of the sample of a given area, the size of the yarn is determined. It is necessary to count the warp threads and to count the picks in the cloth to determine the number of filling threads. Picks often run as high as 60 per inch.

From this discussion it is evident that simple processes of arithmetic are involved such as counting and multiplication. Two tables of measure are used but not in their entirety, In the avoirdupois measure the pound, ounce, dram and grain are significant while in the linear measure the common units are inch and yard. In regard to fractions the prevailing custom is to represent fractions of a yard by 1/8, 2/8, 3/8 etc. and parts of an inch by tenths, for example width of cloth from the loom may be 24.8.

Mr. Samuel S. Dale in a talk on textile arithmetic said that "the textile operations with a few unimportant exceptions are carried on by only six standards, two for length and four for weight: yard, inch, pound, ounce, dram, and grain. Calculations for textile materials in process of manufacture relate principally to length and weight, slightly to area and practically not at all to volume. These are the conditions that simplify calculations to so great a degree in American mills" The yarn count which is based on the relation between weight and length offers some complication. With the exception of the linen count used for woolen yarn in the Philadelphia district, each branch of the textile industry has its distinctive standard.

These standards are:

Cotton	840 yards to the pound
Worsted	560 yards to the pound
Woolen	1600 yards to the pound
Linen	300 yards to the pound
Silk	drams per 1000 yards

The worsted count based on the length of 560 yards is exactly two-thirds of the cotton hank (840 yards). The cotton count of 840 yards and the woolen run of 1600 yards per pound form the basis

Reference: Dale, Samuel S.
"A Talk on Textile Arithmetic"

for our system of sizes. Both the cotton count and the run are easily reduced to equivalents by any of the other three standards. The cotton count is one and one-half times the worsted count so the cotton count can be changed to the worsted count by increasing the cotton count by one-half.

Thus:

No. 20 cotton = No. 30 worsted

No. 36 cotton = No. 54 worsted

The reverse of this operation is a reduction by one-third. Thus:

No. 30 worsted = No. 20 cotton

No. 48 worsted = No. 32 cotton

The cotton hank is 2.8 times the linen hank. It is possible to change from a cotton to a linen basis by multiplying by 2.8.

For example:

No. 10 cotton = No. 28 linen

No. 30 cotton = No. 84 linen

The run of 1600 yards is nearly twice the length of a cotton hank so the run count is approximately one-half the cotton count. This approximate figure serves in many instances but for calculations accuracy is required.

Reference: Dale S. S. "Talk on Textile Arithmetic."

The cotton hank of 840 yards is equal to .525 of the woolen run

No. 1 cotton = .525 run

No. 10 cotton = 5 1/4 run

No. 100cotton = 52 1/2 run

The woolen run system is especially convenient because the length 1600 is exactly 100 times the number of ounces avoirdupois in a pound. Thus 1600 yards to a pound is equivalent to 100 yards to the ounce. A 3 run yarn measures 3 x 1600 yards per pound and 3 x 100 yards per ounce. If the run size of a yarn is known the weight in ounces may be found by simple division. If the warp has 3000 ends and the yarn is 4 run the weight of a yard of warp may be found by dividing 3000 by 400.

3000 ÷ 400 = 7 1/2 (weight in ounces)

The cotton count of 840 yards per pound offers advantages because 840 is divisible by 2,3,4, 5,6,7,8 and 10.

The textile industry calls for calculations which are peculiarly connected with the manufacturing processes. While these operations involve simple operations in arithmetic, it is essential to understand the processes involved and the terms used.

VIII. TYPICAL EXAMPLES

The nature of the arithmetical processes involved in textile calculations may be gained from examples stated by E. A. Posselt.

COTTON
Typical Examples

Cotton yarns have for their standard 840 yards per pound.

No. 1 cotton = 840 yards

No. 2 cotton = 1680 yards

Cotton yarns are often manufactured into 2 ply and 3 ply. In the case of 2 ply the number of yards required for one pound is one-half the amount required in the case of a single thread.

For example: 30S cotton yarn (single) equals 25,200 yards per pound while a 2 ply thread of 30'S cotton requires only 12,600 yards which is the same as the amount required in single 15'S cotton. Thus to find the length of yarn in any ply, divide the given yarn count by the ply number and get the equivalent count in a single thread.

Example: Four ply 20'S or 4/20'S cotton yarn equals the amount called for in single 5'S cotton.

$20 \div 4 = 5$

Rule for finding weight in ounce of a given number of yards of cotton yarn of a known count.-

Reference: Posselt - "The Structure of Fibers, Yarns and Fabrics." Vol II. P. 5

Multiply the given number of yards by 16 and divide by number of yards of cotton yarn of the known count required to balance one pound.

Example: (single yarn) Find the weight of 12,600 yards of 30'S cotton yarn.

12,600 × 16 = 201,600

1lb. 30'S cotton yarn = 25,200

201,600 ÷ 25,200 = 8

Answer: 12,600 yards of 30'S cotton weigh 8 ounces.

Example: (2 ply) Find weight of 12,6000 yards of 2/30'S cotton yarn.

12,600 × 16 = 201,600

1lb. 2/30'S cotton yarn = 12,600

201,600 ÷ 12,600 = 16

Answer: 12,600 yards of 2/30'S cotton yarn weigh 16 ounces.

Examples: (3 ply yarn) Find the weight of 12,600 yards of 3/30'S cotton yarn.

12,600 × 16 = 201,600

1 lb. 3/30'S cotton yarn = 8,400

201,600 ÷ 8400 = 24

Answer: 12,600 yards of 3/30'S cotton yarn weigh 24 ounces.

Rule for finding the weight in pounds of a given number of yards of cotton yarn of a known count.

Reference: Posselt Vol. II p. 6

Divide the given number of yards by the number of yards of the known count required to balance one pound.

Example:(single yarn). Find the weight of 1,260,000 yards of 30'S cotton yarn.

30'S Cotton Yarn = 25,200 yds. to 1 lb.

1,260,000 ÷ 25,200 = 50

Answer: 1,260,000 yards of 30'S cotton yarn weigh 50 pounds.

Example: (2 ply). Find the weight of 1,260,000 yards of 2/30'S cotton yarn.

2/30'S Cotton Yarn = 12,600 yds. to 1 lb.

1,260,000 ÷ 12,600 = 100

Answer: 1,260,000 yards of 2/30'S cotton yarn weigh 100 pounds.

Example: (3-ply). Find the weight of 1,260,000 yards of 3/30'S cotton yarn.

3/30'S Cotton Yarn = 8,400 yds. to 1 lb.

1,260,000 ÷ 8,400 = 150

Answer: 1,260,000 yards of 3/30'S cotton yarn weigh 150 pounds.

Rule:- To find the equivalent size in single yarn for 2, 3 or more ply yarn composed of minor threads of unequal counts, divide the product of the counts of the minor threads by their sum.

Example: Find the equal in single yarn to a two-fold thread composed of single 40'S and 60'S.

40 × 60 = 2400

40 + 60 = 100

2400 ÷ 100 = 24

Answer: A two-fold cotton thread composed of single 40'S and 60'S equals single 24'S

WOOLEN YARNS

Woolen yarns are generally graded by "runs" with 1600 yards as the standard.

TABLE OF RUNS

Runs	Yards to 1 pound
1/4	400
1/2	800
3/4	1200
1	1600
1 1/4	2000
1 1/2	2400
1 3/4	2800
2	3200
2 1/4	3600
2 1/2	4000
2 3/4	4400
3	4800
3 1/4	5200
3 1/2	5600
3 3/4	6000
4	6400
4 1/4	6800
4 1/2	7200
4 3/4	7600
5	8000

WOOLEN YARN.

Typical Examples.

Textile calculations by means of the run system are easy because the standard number 1600 is exactly 100 times the number of ounces in 1 pound.

RULE: To find the weight in ounces of a given number of yards of woolen yarn of a known count, simply multiply the size of the yarn given in run counts by 100 and divide the result into the number of yards given (for which we have to find the weight) and that will give the weight expressed in ounces.

Example: Find the weight of 7200 yards of 4 run yarn.

$$4 \times 100 = 400$$

$$7200 \div 400 = 18$$

Answer: 7200 yards of 4 run yarn weigh 18 ounces.

Rule for finding weight in pounds of a given number of yards of woolen yarn of a known count graded after the run system.

If the weight of a given number of yards and of a given size of woolen yarn, run system is to be calculated in pounds, transfer the result obtained in ounces into pounds or fractions thereof.

Example: Find the weight of 100,000 yards of 6 1/4 run yarn.

$$6\ 1/4 \times 100 = 625$$

$$100{,}000 \div 625 = 160$$

$$160 \div 16 = 10$$

Answer: 100,00 yards of 6 1/4 run yarn weigh 10 pounds.

CUT SYSTEM

Woolen yarn is also graded by the cut system. In the cut system, 300 yards is the basis or standard. If 300 yards of a given woolen yarn weigh 1 pound, we classify it as 1 cut yarn. If 600 yards weigh 1 pound we classify it as 2 cut yarn.

The count of woolen yarn expressed in the cut multiplied by 300 gives as a result the number of yards of respective yarn that 1 pound contains.

TABLE OF LENGTHS FOR WOOLEN YARN

Cut System (From 40 to 50 cut)

Cut	Yards to pound
40	12,000
41	12,300
42	12,600
43	12,900
44	13,200
45	13,500
46	13,800
47	14,100
48	14,400
49	14,700
50	15,000

Rule for finding the weight in ounces for a given number of yards of woolen yarn of a known count figured by the "cut " basis.

Multiply the given yards by 16 and divide the result by the original number of yards for the given count of yarn that 1 pound contains.

Example: Find the weight of 12,600 yards of 40 cut woolen yarn.

12,600 × 16 = 201,600

1 lb. of 40 cut woolen yarn = 12,000 yards

201,600 ÷ 12,000 = 16.8

Answer: 12,600 yards of 40 cut woolen yarn weigh 16.8 ounces.

Rule for finding the weight in pounds of a given number of yards of woolen yarn of a known count graded by the cut basis.

Divide the given number of yards by the original number of yards for the given count of woolen yarn (cut basis) in 1 pound. The result expresses the weight in pound or fraction thereof.

Example: Find the weight of 1,260,000 yards of 40 cut woolen yarn.

40 cut woolen yarn = 12,000 yds. to lb.

1,260,000 ÷ 12,000 = 105

Answer: 1,260,000 yards of 40 cut woolen yarn weigh 105 pounds.

Example: Illustrating Proportion.

Find the equal size in worsted yarn to 20'S cotton yarn.

$$840 : 560 = 3 : 2$$

therefore

$$20 : x = 2 : 3$$

$$2x = 60$$

$$x = 30$$

Answer: A thread of 20'S cotton yarn equals (in size) a thread of 30'S worsted yarn

These examples show that the processes of arithmetic used are very simple and involve mainly the fundamentals. The calculations that apply especially to the textile industry have meaning when the operations which call for the figuring are understood. A text book called "Cotton Mill Mathematics" by Quigley and Smith recommend the following topics for study:

1. Reading numbers
2. Addition of Whole Numbers
3. Sub traction of Whole Numbers
4. Multiplication of Whole Numbers
5. Division of Whole Numbers
6. Multiples, Prime Numbers and Factors
7. Fractions
8. Decimals

9. Analysis of Problems, Equations
10. Percentage
11. Measures of weight, length, time, area and volume
12. Square root
13. Ratio and Proportion
14. Pulleys, gears, belts and levers
15. Calculations which deal particularly with textile industry.

IX. SCHOOLING REQUIRED

The next problem is to find out how much mathematics is needed by the ordinary worker in his daily occupation. In a bulletin issued by the United States Department of Labor 157 different types of workers are listed for the woolen and worsted division alone. The qualifications needed for the particular tasks as well as schooling required are given. In only 20 instances do we have schooling mentioned at all and of these 7 are required to be able to read and write 12 to have common school training and 1 to have some knowledge of chemistry as well as common school training.

The next line of approach was to have conferences with brokers and other officials in the wool business on Summer Street. In every instance it was learned that wool was purchased in bags and the unit of measurement was the pound. In the case of foreign wools subject to duty the duty was reckoned on basis of the pound.

One wool house employing from 25 to 40 persons estimated that about one third could be classed as skilled workers and the rest as unskilled. The agent voiced an opinion that the more a person knew about the wool business the more likely he was to be given a job in the establishment. His opinion was that you could never know too much about your line of work.

X. VISITS TO MANUFACTURING PLANTS

The next plan was to visit four manufacturing plants to see the workers at their tasks and thus get a better idea of the amount of figuring done on the job. In visiting the manufacturing establishments the aim was to become better acquainted with the process of manufacture and to get the following information:

1. Articles purchased and how purchased.
2. Articles manufactured.
3. The units of measurement used in the manufacture.
4. Articles sold and how sold.
5. Number employed and the percentage that do figuring to a great extent.

Report of Visit to Pacific Mills Lawrence, Mass.

Pacific Mills -- Worsted Division

The information gained here was from a conference with a member of the office force. Due to a recent strike the factory was not running at full capacity. There were only 1500 employed in this division as compared to 3300 in September. Of these 20 were employed in the office force and 20 in the cost department. When asked how much schooling was needed to perform the usual tasks the reply was

"nighty little." The workers usually learn everything needed on the job itself. Most of them start at the bottom and if they become proficient in their particular line, might gradually be promoted to more desirable positions in the industry.

PACIFIC MILLS

Worsted Division

1. Articles Purchased	How Purchased
Dye Stuffs	by pound
Heavy Chemicals	by pound
Wool in bags or bale	by pound
Silk yarn	by ounce and pound
Fancy Worsted yarn	by pound
Cotton yarn	by pound
Machines	by pound
Oils	by pound

2. Articles Manufactured

Ladies' dress goods

Ladies' coating material

Men's suiting

UNITS OF MEASURE USED IN MANUFACTURE

Woolen yarn	Grain
Sliver light or heavy	Dram
Yarn count worsted	560 yds. per pound
Woolen run	1600 yds. per pound

PACIFIC MILLS WORSTED DIVISION

Width of finished cloth	Inches
Length of cloth	Yards and eighth yards
Weight of cloth	Ounces per yard
Threads on warp	Number per inch
Picks of filling	Number per inch

3. Articles sold	How sold
Ladies' dress goods	By yard
Coating	By yard
Suiting	By yard

4.

Number employed	1500
Number in office	20
Number in cost department	20
Total number responsible for figuring	75
Percentage responsible for figuring	5%

5. Summary of Units of Measurement Used in Manufacturing Process.

Linear Measure

Inch

Yard

Avoirdupois Measure

Grain

Dram

Ounce

Pound

ARLINGTON MILLS

Lawrence, Mass.

1. Articles Purchased	How Purchased
Dye Stuffs	By pound
Heavy Chemicals	By pound
Wool	By pound
Crude Oils	By pound
Machines	By pound

2. Articles Manufactured

Ladies' dress goods

Coating

Men's suiting

3. Units of Measurement Used in Manufacturing

Woolen yarn	Grain
Sliver, light or heavy	Dram
Worsted yarn count	Yards per pound
Woolen run	Yards per pound
Width of cloth in loom	Inches & tenths of inch
Width of finished cloth	Even inches
Length of cloth in loom	Yards & eigths of yards
Length of finished goods	Yards & eighth of yard
Weight of cloth	Ounces per yard
Threads of warp	Number per inch
Picks of filling	Number per inch
Twist (hardness)	Number per inch

4. Articles sold — How sold

Ladies' dress goods	By yard
Ladies' coating	By yard
Men's suiting	By yard

5. Number employed 6,500

Percentage responsible for figuring 20%

Accuracy important in

Chemical Department

Dye House

Cloth Analysis

Weighing

6. Units of Measurement Used in Manufacture

Linear Measure

Inch

Yard

Avoirdupois Measure

Grain

Dram

Ounce

Pound

WOOD WORSTED MILLS

Lawrence, Mass.

1. Articles Purchased	How Purchased
Dye Stuffs	By pound
Wool	By pound
Chemicals	By pound
Crude Oils	By pound
Soap	By pound
Machines	By unit

2. Articles Manufactured

Women's dress goods

Coating

Men's suiting

3. UNITS OF MEASUREMENT USED IN MANUFACTURE

Woolen yarn	Grain
Sliver, light or heavy	Dram
Worsted yarn count	Yards per pound
Woolen run	Yards per pound
Width of cloth in loom	Inches and tenth of inch
Width of finished cloth	Even inches
Length of clothing loom	Yards and eighths of yard
Length of finished cloth	Yards and eighths of yard
Weight of cloth	Ounces per yard
Twist (hardness)	Numbers of turns per inch
Threads of warp	Number per inch
Picks of filling	Number per inch

WOOD WORSTED MILLS

4. Articles sold — How sold

Ladies' dress goods — By yard

Coating — By yard

Suiting — By yard

5. Number employed — 2000 to 6500

Percentage responsible for figuring — 20%

Most extensive figuring needed in following departments:

Department for rating fabrics

Dye department

Selling department

Office

6. UNIT OF MEASUREMENT USED

Linear Measure

Inch

Yard

Avoirdupois Measure

Grain

Dram

Ounce

Pound

STIRLING MILLS

Lowell, Mass.

At this mill grease wool was bought in 300 pound bags. The wool is weighed after the washing and carbonising to estimate the loss from shrinking. After it is washed and dried the wool is carried through the burr picker. Then it is bagged, weighed and stored for future use.

The man in charge of the spinning room weighs a sample of the woolen yarn to make sure that the yarn has the proper weight according to the length. He has a table for runs and grains of 50 yards. He usually makes what he calls a half-draft by using 25 yards instead of 50 yards. He uses a yard stick for length and grain scale for weight.

In the room where the yarn is wound on the Jack Spools the time keeper weighs the empty spools and the full spools. These weights are recorded beside the name of the persons who fill the spools.

The bookkeeper in the office subtracts the weights of empty spools from weights of full spools and adds the differences in order to determine the wages for piece work. This figuring involves denominate numbers as shown by the following list.

Full Spool	Empty Spool
32 lbs. 8 oz.	5 lbs. 0 oz.
30 lbs. 8 oz.	4 lbs. 10 oz.
31 lbs. 8 oz.	4 lbs. 13 oz.
32 lbs. 10 oz.	5 lbs. 0 oz.
31 lbs. 10 oz.	4 lbs. 10 oz.
31 lbs. 0 oz.	4 lbs. 8 oz.
31 lbs. 4 oz.	4 lbs. 13 oz.

In the fulling room the fuller receives the cloth from the loom and has to finish the cloth to a required width and length. The pressure and time involved when cloth is exposed on the machine determine the shrinkage. The fuller watches the shrinkage in a limited period of time, and estimates the time needed for the required length and width. The goods had a given weight per yard. For example - one bolt of goods measuring 69 yards had a weight of 51 ounces or an average of 11 ounces per yard. Another bolt of 63 yards weighed 63 pounds, that is, 16 ounces per yard.

The persons who seem to do most of the figuring in order of importance outside of the agent who is responsible for the success of the enterprise are as follows:

1. Bookkeeper
2. Fuller
3. Spinner
4. Weigher of wool and measurer of finished goods
5. Time keeper

STIRLING MILLS

Lowell, Mass.

1. Articles Purchased	How Purchased
Ammonia	by pound
Wool	by pound
Sulphuric	by pound
Soap	by pound
Dye Stuffs	by pound
Soda Ash	by pound
Machines	by unit
Oil	by pound
Salt	by pound
Alkali	by pound
Boards	by unit
Tubes	by unit
Ropes	by pound
Twine	by pound
Bobbins	by unit
Coal	by pound
Shuttles	by unit

2. Articles Manufactured

Dress goods

Coating

STIRLING MILLS

Lowell, Mass.

3. UNITS OF MEASUREMENT USED IN MANUFACTURING PROCESS

Woolen yarn	Grain
Sliver, light or heavy	Dram
Worsted yarn count	Yards per pound
Woolen run	Yards per pound
Width of cloth in loom	Inches and tenths of inch
Width of finished cloth	Even inches
Length of cloth in loom	Yards and eighths of yard
Length of finished goods	Yards and eighths of yard
Weight of cloth	Ounces per yard
Threads of warp	Number per inch
Picks of filling	Number per inch
Twist (hardness)	Number of turns per inch

4. Articles Sold	How Sold
Cloth No. 561	Bolts by yard
Cloth No. 1171	Bolts by yard

5. Total Number Employed 200

Number responsible for weighing and measuring 5

Number responsible for figuring to a great extent 2

Percentage responsible for figuring 2 1/2%

STERLING MILLS

Lowell, Mass.

6. Summary of Units used in the Manufacturing Process.

Linear Measure

Inch

Yard

Avoirdupois Measure

Grain

Dram

Ounce

Pound

The four mills visited were the Arlington, Pacific and Wood Worsted Mills of Lawrence, Massachusetts, and the Stirling Mills of Lowell, Massachusetts. In these mills employing approximately fourteen thousand (14,000) persons not over 20 percent did figuring to any extent. Many entered the industry with very little elementary education, if any. Whatever figuring was necessary came naturally with the understanding of the processes involved. Beginners usually start with mere routine work and as they show initiative are often promoted to more responsible positions. The figuring required involves mostly simple processes in arithmetic. The units of

measurement most commonly used are grain, dram, ounce, pound, inch, and yard. The square inch is used in cloth analysis. The table of measure is seldom used in its entirety and examples calling for reduction from one denomination to another are usually taken care of by one member of the office force. The question of yarn counts causes concern but tables in the hand of the spinner make this figuring a matter of weighing and reading the table. Automatic machines makes much of the work a matter of routine.

Techinal schools do much to raise the intelligence of the average worker, but the greatest contribution is in training leaders and research workers.

XI. SUMMARY

The study of the "Textile Industry" is of vital interest to all because it supplies clothing, one of the fundamental needs of mankind. Then too, it is closely bound up with the economic development of America in general and New England in particular.

The industry is broad in scope and deals with all types of materials which have been spun or woven. Textiles are divided according to their origin into animal fibers, vegetable fibers, and mineral fibers. America leads in the manufacture of woolen and cotton cloth. The manufacture of linen and silk goods seems to be restricted somewhat to the district around Philadelphia.

While some figuring is done from the time the sheep are sheared on the ranch or the cotton is picked from the fields until it reaches the factories most of the calculation is concerned with the manufacturing process. In this figuring meaning should come first. There should be a clear understanding of the processes of manufacture and then the figuring is comparatively simple.

The figuring involves simple processes in arithmetic such as counting, reading numbers, addition, subtraction, multiplication, and division.

The fractions used are simple, in fact the fraction 1/8 seems to be the preferred fraction though 1/4 is used occasionally. The six units of measure used in the manufacturing process are grain, dram, ounce, pound, inch, and yard.

Four woolen mills were visited and it was learned that the average worker did little or no figuring. Not more than 20 per cent of the thousands of workers needed a knowledge of the simplest processes of arithmetic.

The Textile schools are indispensable in training leaders and research workers and thus enabling America to take her place as the foremost manufacturing country in the world.

XII. CONCLUSION

From the study of the textile industry the following conclusions were formed:

(1.) The English yard-pound system is used rather than the metric system.

(2.) Only six units are used in the manufacture of cloth, two for length and four for weight. The six units are yard, inch, pound, ounce, dram, and grain. The tables of measure are not used in their entirety. The six units used are found in two tables of measure.

(3.) There seems to be no use for complicated fractions. The fraction 1/8 is the fraction for giving length of goods.

(4.) Special scales are used which record length of goods in yards and eighths of yard and width in inches and tenths of inch.

(5.) Situations do arise where denominate numbers are used but that detail is usually handled by one member of the office force.

(6.) The use of tables makes figuring unnecessary in many instances.

(7.) Only a very small proportion of the workers do any figuring at all, but the figuring done must be done accurately.

(8.) Knowledge of the industry is generally learned from shop experience and is a prerequisite for understanding the calculations to be made, in other words meaning comes first and then knowledge of the arithmetic needed.

(9.) The special calculations peculiar to the textile industry do not seem to be the work of the public schools but rather of specialized technical schools.

XIII. GLOSSARY

1. Carding - "Carding is the final stage of cleansing the cotton, as well as the process by means of which the fibers, which so far rest in all possible directions, (crossways or against each other) are arranged side by side or parallel."

2. Card - A toothed instrument for disentangling and laying parallel the fibers of wool or cotton preparatory to spinning.

3. Draft - The elongating of one or more ends pf sliver or slubbing delivered by a pair of rollers into one thinner end by means of another pair of rollers.

4. Ply is the term used to designate thread made by twisting two or more threads together. The number thus combined is indicated for example 2-ply etc.

5. Ring spindle is a special machine designed for holding the thread in spinning process. The type of spindles used is of great importance for making good and evenly twisted yarn.

6. Sliver - A long ribbon of cotton, wool, flax etc. dramn out by means of carding, combing, or drawing and run into a can or wound on a ball. The sliver has no twist and clings together by the natural crimp which the fibers possess.

Reference: Posselt, E. A. Vol I. P. 29

7. Slubbing is the sliver of cotton after it has passed through the first roving machine.

8. Twist - the number of turns per inch in a thread or yarn.

9. The terms 3/8 blood, 1/4 blood, are used to indicate the grade of combing wool. In order to increase the length of combing wool and obtain better quality, sheep are crossed by different breeds. There are three grades in the merino division. These are as follows:

(1) 3/8 blood, fine, the finest of the long staple.

(2) 1/4 blood, medium, not quite so fine.

(3) Common or low, of combing length and a little finer than the combing wool of the mutton breeds.

XIV. BIBLIOGRAPHY

1. Dale, Samuel S.
The Metric Failure in the Textile Industry.
D. Van Nostrand Company
New York 1904

2. Dale, Samuel S.
A Talk on Textile Arithmetic. Delivered before the Laurence Textile School May 25, 1908.
Article 510 in a special compilation of pamphlets labelled, Wool Tariffs, Wool Labellings, Weights and Measures.

3. Fobiger, William A.
Boston Evening Transcript, Jan. 21, 1932.

4. Fitzgerald, O. A.
Century of Progress in Sheep Breeding.
Boston Evening Transcript, Jan. 21, 1932.

5. Fowler, Carl G.
New England Faith in the Present.
Boston Evening Transcript, Jan. 21, 1932.

6. Posselt, E. A.
The Structure of Fibers, Yarns and Fabrics.
E. A. Posselt author and publisher.
2151 No. Twenty-first Street, Philadelphia,
1891

Bibliography - Continued

7. Quigley, Thomas H. and Smith, W. S.
Cotton Mill Mathematics
Smith Hammond & Company
Atlanta, Georgia. 1927

8. Search, Theodore C.
Textile Education in America. An
address delivered in Boston Jan. 10, 1895.
Printed by
George H. Buchanan & Company.
Philadelphia 1895

9. Additional Articles from
Boston Evening Transcript
March 3, 1932 - March 18, 1932

10. Bulletin
American Woolen Company
"From Wool to Cloth"
American Woolen Company
Wood Worsted Mills,
Lawrence, Mass.

11. Bulletin
Foreign Department of Scientific
and Industrial Research.
Report for the year 1930 - 1931
Presented by the Lord President of the
Council to Parliament by command of
His Majesty, December, 1931.

Bibliography - Continued

London
Published by His Majusty's Stationery
Office 1931.

12. School Bulletins
Bulletins of Lowell Textile Institute
(1) February, 1931
(2) August, 1931

13. State Bulletin
Commonwealth of Massachusetts
Department of Labor & Industries
Monthly Survey - Representative Manufacturing Establishments
March, 1932

(3) United States Government Bulletins
1. United States Department of
Agriculture - Report No. 66
Sheep and Wool
A Review of the Progress of American
Sheep and Husbandry
by
J. R. Dodge, Special Agent
Government Printing Office - 1900
(2) Department of Commerce
Circular of the Bureau of Standards.
S. W. Stratton, Director - No. 47

Bibliography - Continued

Units of Weights and Measure

1st Edition issued July 1, 1914

Government Printing Office - 1917

(3) United States Department of Commerce

Circular of Bureau of Standards - No. 70

Materials for the Household

1st Edition issued December 5, 1917

Government Printing Office

Washington, D. C. - 1917

(4) United States Department of Labor

Description of Occupations

Textile and Clothing - No. 7

Government Printing Office

Washington, D. C. - 1918

(5) United States Department of Labor

W. N. Doak, Secretary

Bureau of Labor Statistics

Trend of Employment - February, 1932

Government Printing Office

Washington, D. C. - 1932

(6) Tariff Act of 1930

Government Printing Office

Washington, D. C. - 1930

Bibliography - Continued

(7) United States Bureau of Labor Statistics
Handbook of Labor Statistics- No. 541 - 1931

(8) United States Bulletin Bureau of Labor- No. 533